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(71) Applicant: **HITACHI, LTD.**
Chiyoda-ku, Tokyo 100 (JP)

(72) Inventors:
- **Oguni, Kensaku**
  Shimizu-shi (JP)
- **Urata, Kazumoto**
  Shizuoka-shi (JP)
- **Muramatsu, Masatoshi**
  Shimizu-shi (JP)
- **Endo, Takeshi**
  Shimizu-shi (JP)
- **Matsushima, Hiroaki**
  Ryugasaki-shi (JP)

(74) Representative:
Finck, Dieter, Dr.Ing. et al
Patentanwälte v. Füner, Ebbinghaus, Finck
Mariahilfplatz 2 - 3
81541 München (DE)

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(54) **Refrigeration cycle using a non-azeotrope refrigerant**

(57) A refrigeration cycle using a non-azeotrope refrigerant comprises a compressor (1), a heat-source-side heat exchanger (2), a use-side heat exchanger (20a, 20b), a refrigerant pressure reducing apparatus (7), a refrigerant receiver (6) disposed between a side of said heat-source-side heat exchanger (2) and said use-side heat exchanger (20a, 20b), whereby said side is opposite to another side of said heat-source-side heat exchanger (2) connected to said compressor (1), a composition ratio detecting means (8) arranged for detecting a composition ratio of the refrigerant, and composition ratio control means (10 to 15, 40 to 44). The composition ratio detecting means (8) is disposed between said heat-source-side heat exchanger (2) and said receiver (6). The composition ratio control means (10 to 15, 40 to 44) are arranged for taking out gas refrigerant from said receiver (6) on the basis of the composition ratio of the refrigerant detected by said composition ratio detecting means (8) so as to vary the refrigerant composition ratio mainly used in said refrigeration cycle.

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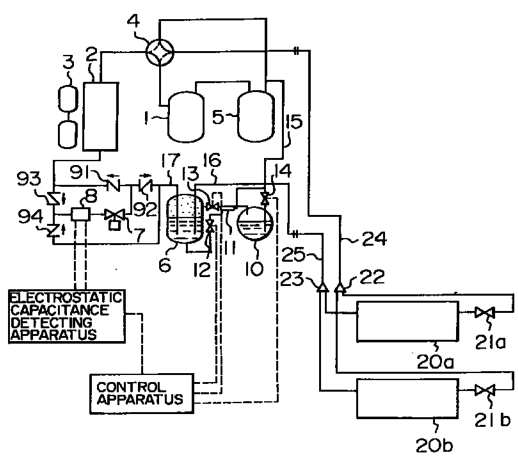

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Description

The invention relates to a refrigeration cycle using a nonazeotrope refrigerant according to the pre-characterizing portion of claim 1.

First, a case in which a non-azeotrope refrigerant is used as a working medium will be explained. The non-azeotrope refrigerant is a refrigerant in which two or more types of refrigerants having different boiling points are mixed, and has characteristics shown in Fig. 3. Fig. 3 is a vapor-liquid equilibrium diagram illustrating characteristics of a nonazeotrope refrigerant in which two types of refrigerants are mixed. The horizontal axis indicates the composition ratio X of a refrigerant having a low boiling point, and the vertical axis indicates temperature. With pressure as a parameter, a saturation vapor line and a saturation liquid line exist in a high temperature region indicated by pressure P_H when, for example, pressure is high and when, conversely, pressure is low, these lines exist in a low temperature region indicated by pressure P_L. The composition ratio X = 0 indicates that the refrigerant is formed of only a high-boiling-point refrigerant, and the composition ratio X = 1.0 indicates that the refrigerant is formed of only a low-boiling-point refrigerant. In a mixture refrigerant, as shown in Fig. 3, a saturation liquid line and a saturation vapor line are determined by the composition thereof. The area below the saturation liquid line indicates the supercooled state, and the area above the saturation vapor line indicates the superheated state. The portion surrounded by the saturation liquid line and the saturation vapor line is a two-phase state of liquid and vapor. In Fig. 3, X_0 denotes the composition ratio of a refrigerant sealed in a refrigeration cycle. Points P1 to P4 indicate the typical points of the refrigeration cycle, and point P1 indicates a compressor outlet portion; point P2 indicates a condenser outlet portion; point P3 indicates an evaporator inlet portion; and point P4 indicates a compressor inlet portion.

An explanation will be given below of problems relating to leakage out of the refrigeration cycle, to variations in the composition of a circulating refrigerant within the refrigeration cycle in a non-steady state such as at the start-up time of the refrigeration cycle, and to refrigeration cycle operation control.

The leakage of a refrigerant out of the refrigeration cycle is not none even in a hermetically sealed type air-conditioner or refrigerator. In Fig. 3, point A indicates the two-phase portion in the refrigeration cycle, in which the liquid of composition X_{a1} and the vapor of composition X_{a2} exist. If the mixture refrigerant should leak out of a heat-transfer tube of a heat exchanger or from a connection tube of a component, it would be a refrigerant of composition ratio X_{al} in the case of liquid leakage, and a refrigerant of composition ratio X_{a2} in the case of vapor leakage. Therefore, the composition ratio of the refrigerant remaining within the refrigeration cycle differs depending upon whether liquid or vapor leaks.

Fig. 4 is an illustration of a problem caused by the leakage of a refrigerant to the outside. If liquid leaks, the remaining mixture refrigerant enters the state of X_1 in which the ratio of a low boiling-point refrigerant is large; if vapor leaks, the remaining mixture refrigerant enters the state of X_2 in which the ratio of a high boiling-point refrigerant is large. In Fig. 2, X_0 indicates the composition ratio of a refrigerant which is sealed in initially. If a state in which the composition is X_0 is compared with a state in which the composition is X_1 at the same pressure, the temperature when the composition is X_1 is lower. If, however, a state in which the composition is X_0 is compared with a state in which the composition is X_2 at the same pressure, the temperature when the composition is X_2 is higher.

Fig. 5 shows general characteristics of a refrigeration cycle with respect to the composition ratio of the low boiling-point refrigerant. When the composition ratio X becomes larger, and therefore heating and cooling performance improves.

If the refrigerant leaks out of the refrigeration cycle in which a non-azeotrope refrigerant is used as a working medium, as described above, the composition ratio of the refrigerant remaining within the refrigeration cycle changes from the initial composition ratio, i.e., from the designed composition ratio for the apparatus depending upon leaked portions. Even if there is no leakage to the outside, there is a possibility that the composition ratio of the refrigerant circulating within the refrigeration cycle may vary in the non-steady state of the refrigeration cycle.

Changes in the composition ratio of the refrigerant within the refrigeration cycle cause problems; for example, heating and cooling capacity is varied, or pressure or temperature becomes abnormal. Therefore, the refrigeration cycle must be controlled properly.

Since a chlorofluorocarbon refrigerant containing chlorine is considered to damage an ozone layer, a non-azeotropic mixture of a chlorofluorocalcium refrigerant containing no chlorine has been proposed as an alternative refrigerant. A consideration must be given to the mixture refrigerant in order to safeguard the earth environment.

The control of a refrigeration cycle in which a non-azeotropic mixture is used as a working medium is disclosed in, for example, Japanese Patent Unexamined Publication Nos. 59-129366, 61-213554, and 64-58964.

Japanese Patent Unexamined Publication No. 59-129366 discloses that an electrostatic capacitance sensor is used as a means for detecting the composition of a refrigerant circulating within the refrigeration cycle. Further, it is disclosed that the refrigeration cycle comprises a first liquid receiver and a second liquid receiver, an electric heater being disposed in the second liquid receiver. When the outdoor air temperature is low during a heating operation, the electric heater of the second liquid receiver is operated and controlled so that a set refrigerant concentration is reached.

Disclosed in Japanese Patent Unexamined Publication No. 61-213554 is an apparatus comprising a separator for separating a low-boiling-point refrigerant, a liquid receiver for storing a low-boiling-point refrigerant, and a control valve for returning the refrigerant from the liquid receiver, which apparatus controls the composition of the refrigerant on the basis of the temperature of an element to be cooled.

Disclosed in Japanese Patent Unexamined Publication No. 64-58964 is a mixture refrigerant composition variable refrigeration cycle in which the upper portion of the liquid receiver is connected to a refrigerant tank and the lower portion of the liquid receiver is connected to the refrigerant tank, which refrigeration cycle comprises a refrigerant tank capable of exchanging heat with a gas pipe through which a heat-source-side heat exchanger is connected to a use-side heat exchanger, a liquid receiver and the like.

As described above, in the refrigeration cycle in which a nonazeotrope refrigerant is sealed in, the composition ratio of the refrigerant within the refrigeration cycle may vary when the refrigerant leaks out of the refrigeration cycle or during the non-steady operation of the refrigeration cycle. The capacity of the refrigeration cycle can be varied by making the composition variable. Therefore, to obtain a high-capacity refrigeration cycle, it is important to control the refrigerant composition ratio within the refrigeration cycle so as to realize a stable operation. There has been a demand for a method of varying this composition ratio inexpensively. Further, it is necessary to use a refrigerant which does not contain chlorine and does not damage the ozone layer, in which a consideration is given to safeguard the earth environment.

US-A-5 186 012 discloses a heat pump system using a non-azeotropic refrigerant mixture comprising a main refrigeration circuit, an engine coolant circuit, and a refrigerant rectifier circuit interfacing with the main refrigeration circuit and the engine coolant circuit. The refrigerant rectifier circuit comprises in order of decreasing relative elevation a condenser, a storage vessel in communication with a condenser, a rectifier in communication with a storage tank and a condenser, a receiver vessel in communication with a rectifier, and a boiler in communication with the rectifier and the receiver vessel. A ratio detecting means is disposed in the receiver. The refrigerant rectifier circuit is used to adjust the relative concentrations of lower boiling point refrigerant, and higher boiling point refrigerant in the non-azeotropic refrigerant mixture thereby changing the cooling or heating capacity of the heat pump system. However, in the system according to US-A-5 186 012 only liquid refrigerant can be taken from the receiver.

In general according to the prior art adjustment of the relative concentrations of the components of a non-azeotropic refrigerant is carried out actively operating only with one phase of the refrigerant. Therefore, the prior art has the problem that the width of the adjustment of the concentration is narrow.

It is an object of the invention to provide a refrigeration cycle using a non-azeotrope refrigerant, which refrigeration cycle ensures a wide range of adjustment.

This object is achieved by a refrigeration cycle according to claim 1.

In the refrigeration cycle according to the invention not only liquid refrigerant flow between the heat-source-side and the use-side through the receiver is ensured but also gas refrigerant can be taken from the receiver in response to the composition ratio of the refrigerant detected by the composition ratio detecting means. This allows adjustment of the refrigerant composition ratio in a wide range. Moreover it is advantageous that the composition ratio detecting means is not disposed in the receiver but between the heat-source-side heat exchanger and the receiver. This arrangement of the composition ratio detecting means allows a more accurate measurement of the refrigerant composition ratio mainly used in the refrigeration cycle.

Advantageous and preferred embodiments of the refrigeration cycle according to the invention are subject matter of claims 2 to 5.

Preferred embodiments of the invention will now be described with respect to the accompanying drawings in which

Fig. 1 is a schematic view of a refrigeration cycle having a control apparatus for controlling the composition of a non-azeotrope refrigerant;

Fig. 2 is a longitudinal sectional view of a refrigerant circuit for controlling the composition of the refrigerant;

Fig. 3 is a diagram illustrating the characteristics of a non-azeotrope refrigerant;

Fig. 4 is a diagram illustrating the relationship between the composition of the non-azeotrope refrigerant and temperature;

Fig. 5 is a diagram illustrating the characteristics of a refrigeration cycle in which a non-azeotrope refrigerant is used;

Fig. 6 is a diagram illustrating the characteristics of a non-azeotrope refrigerant;

Fig. 7 shows an example of the composition of three-type mixture refrigerant;

Fig. 8 is a sectional view of an electrostatic capacitance type composition ratio detecting sensor;

Fig. 9 is a diagram illustrating the relationship between the composition of the non-azeotrope refrigerant and the electrostatic capacitance value;

Fig. 10 is a flowchart illustrating the control of the composition of the non-azeotrope refrigerant;

Fig. 11 is a schematic view of a refrigeration cycle having a control apparatus for controlling the composition ratio of the non-azeotrope refrigerant;

Fig. 12 is a detailed view of a refrigerant separation circuit;

Fig. 13 is a flowchart illustrating the control of the composition ratio of the non-azeotrope refrigerant;

Fig. 1 illustrates a refrigeration cycle in which a plurality of indoor machines are connected to one outdoor machine in accordance with a first embodiment of the present invention. Referring to Fig. 1, reference numeral 1 denotes a compressor; reference numeral 2 denotes an outdoor heat exchanger; reference numeral 3 denotes an outdoor air blower; reference numeral 4 denotes a four-way valve; reference numeral 5 denotes an accumulator; reference numeral 6 denotes a receiver; and reference numeral 7 denotes an outdoor refrigerant control valve which acts as a pressure reducing mechanism during a heating operation. Reference numeral 8 denotes a sensor for detecting the composition of a non-azeotrope refrigerant; reference numeral 10 denotes a refrigerant tank; reference numeral 11 denotes a cooling unit; reference numerals 12, 13 and 14 denote open/close valves; reference numerals 15, 16 and 17 denote pipes; reference numerals 91, 92, 93 and 94 denote check valves which constitute an outdoor machine. Reference numerals 20a and 20b denote indoor heat exchangers; reference numerals 21a and 21b denote indoor refrigerant control valves which act as a pressure reducing mechanism during a cooling operation; reference numerals 22 and 23 denote refrigerant distribution units; and reference numerals 24 and 25 denote pipes for connecting indoor machines to outdoor machines. The illustration of the indoor air blower is omitted.

Next, a detecting apparatus in which an electrostatic capacitance sensor 8 for detecting the composition of a non-azeotrope refrigerant is used, and a control apparatus for controlling the open/close valves 12, 13 and 14 are disposed on the outdoor side. In Fig. 1, the illustration of the control system of the refrigeration cycle is omitted. A refrigerant which does not contain chlorine and does not damage the ozone layer is used as the refrigerant. In this embodiment, an example in which HFC32 and HFC134a are used as the non-azeotrope refrigerant will be explained.

Next, the flow of the refrigerant will be explained. During a cooling operation, the refrigerant discharged from the compressor flows in the following order: the four-way valve 4 → the outdoor heat exchanger 2 → the check valve 93 → the composition sensor 8 → the outdoor refrigerant control valve 7 → the check valve 92 → the receiver 6. The refrigerant is distributed by a refrigerant distribution unit 23, a part of the refrigerant flows in the order: the indoor heat exchanger 20a → the indoor refrigerant control valve 21a, and the other flow in the order: the indoor heat exchanger 20b → the indoor refrigerant control valve 21b. They merge in a distribution unit 22 and flow in the order: the pipe 24 → the four-way valve 4 → the accumulator 5, and return to the compressor. At this time, the indoor heat exchangers 20a and 20b act as evaporators and a cooling operation is performed.

On the other hand, during a heating operation, the refrigerant discharged from the compressor flows in the following order: the four-way valve 4 → the pipe 24 → the distribution unit 22. A part of the refrigerant flows in the order: the indoor refrigerant control valve 21a → the indoor heat exchanger 20a, and the other flow in the order: the indoor refrigerant control valve 21b → the indoor heat exchanger 20b. They merge in a distribution unit 23 and flow in the order: the pipe 25 → the receiver 6 → the check valve 94 → the composition sensor 8 → the outdoor control valve 7 → the check valve 91 → the outdoor heat exchanger 2 → the four-way valve 4 → the accumulator 5, and return to the compressor. At this time, the indoor heat exchangers 20a and 20b act as condensers and a heating operation is performed.

The details of the low-boiling-point refrigerant separation circuit of Fig. 1 are shown in Fig. 2. In Fig. 2, a cooling unit 11 is a double-pipe heat exchanger. When a liquid refrigerant is stored in a refrigerant storage tank 10, the open/close valves 12 and 13 are opened. In this case, the liquid in the bottom of the receiver 6 flows out through the open/close valve 12, and the liquid is formed into a low-temperature refrigerant by the pressure reducing effect of the open/close valve 12 and guided into the inner pipe of the cooling unit 11. On the other hand, gas inside the receiver 6 flows out through the open/close valve 13 and is guided into the outer pipe of the cooling unit 11. The low-temperature refrigerant gas of the inner pipe exchanges heat with the gas of the outer pipe, and the low-temperature refrigerant is gasified and guided into the accumulator 5 through the pipe 15. The condensed liquefied refrigerant of the outer pipe is guided into the refrigerant storage tank 10. When a predetermined amount of liquid refrigerant is stored in the refrigerant storage tank 10, the open/close valves 12 and 13 are closed. The above operation and effect make it possible to store the liquid refrigerant in the refrigerant storage tank 10. To discharge the liquid refrigerant from the refrigerant storage tank 10, the open/close valve 14 is opened so that the liquid refrigerant can be discharged to the accumulator 5 through the pipe 15.

The composition varying effect will be explained below.

The state of the refrigerant inside the receiver, which is made clear by the experiment conducted by the inventors of the present invention, will now be explained using a cooling operation as an example. Gas and liquid flow into the receiver 6 from the pipe 17, and the gas rises in the liquid layer inside the receiver 6, forming a gas layer. Then, the gas is condensed by the inner wall of the receiver 6 and liquefied. Thereafter, the gas is formed into only liquid in an outlet pipe 16 and flows out. The experimental results show that when the refrigerant dryness of the inlet is great, the liquid disappears inside the receiver 6, and when the refrigerant dryness is small, the receiver 6 is filled with the liquid. The experiment also revealed that the variation of the dryness with respect to the variation in the amount of liquid is 0.01 or less. That is, the dryness of the refrigerant which flows into the receiver is very small.

Fig. 6 illustrates changes of the state of the refrigerant in a refrigerant passage from the condenser to the receiver when a non-azeotrope refrigerant is used as a thermal medium. The horizontal axis indicates the composition ratio X of the lowboiling-point refrigerant, i.e., HFC32, and the vertical axis indicates temperature, with pressure being constant. The state X = 0 indicates a state in which only HFC134a is contained in the refrigerant, and the state X = 1 indicates a state in which the refrigerant is formed of only HFC32. In the non-azeotrope refrigerant, as shown in the figure, the temperature of the saturation vapor differs from that of the saturation liquid at the same pressure. The composition ratio X_0 indicates the composition ratio of the refrigerant sealed in the refrigeration cycle. Point A indicates the state of the inlet of the condenser; point B indicates the condensation start point; point C indicates the state of the inside of the receiver; and point D indicates the state of the outlet of the cooling unit. Point C, as described above, indicates that the flow rate of the liquid is very small. Point E indicates the liquid state inside the receiver, and the composition ratio of HFC32 is X_1. Point F indicates the gas state, and the composition ratio of HFC32 is X_g. It can be seen that the composition ratio of gas at point F is greater than the composition ratio X_0 of the refrigerant sealed in the refrigeration cycle, and the composition ratio in the refrigeration cycle can be varied by taking out gas.

In Figs. 1 and 2, a gas refrigerant having a large composition ratio of HFC32 taken out from the upper portion of the receiver 6 is liquefied in the cooling unit 11 and stored in the tank 10. As a result, the composition ratio of the refrigerant within the refrigeration cycle becomes smaller than X_0. When the composition ratio of the refrigerant within the refrigeration cycle is smaller than X_0, it is possible to return the refrigerant having a large composition ratio of HFC32 to the refrigeration cycle by opening the open/close valve 14.

As described above, the refrigerant composition ratio in the main refrigeration cycle can be varied by taking out or returning the gas refrigerant inside the receiver.

Although the above-described embodiment describes a case in which a mixture refrigerant of two types of refrigerants, i.e., HFC32 and HFC134a, are used as a refrigerant, the present invention may be applied to a mixture refrigerant of more than two types. For example, the present invention may be applied to a threetype mixture refrigerant of HFC32, HFC125 and HFC134a shown in Fig. 7. The numeric values shown in Fig. 7 indicate weight percentage (%) of HFC32, HFC125 and HFC134a, and a mixture refrigerant of various weight percentages may be considered. Of HFC32, HFC125 and HFC134a, the boiling points of HFC32 and HFC125 are higher than that of HFC134a, and therefore the present invention utilizing the difference between the boiling points of mixed refrigerants may be applied. HFC32 and HFC125 exhibit azeotropic characteristics which can be regarded as a single refrigerant, and the abovedescribed mixture refrigerant can be assumed as a mixture refrigerant of the azeotrope refrigerant of HFC32 and HFC125, and HFC134a. The composition varying function of the present invention may be exhibited for a mixture refrigerant of HFC32, HFC125 and HFC134a. In Figs. 1 and 2, gas in the upper portion of the receiver 6 is a low boiling-point refrigerant having a large refrigerant composition ratio, whose compositions of HFC32 and HFC125 from among the three types of refrigerants are large. The gas having large compositions of HFC32 and HFC125, taken out from the upper portion of the receiver 6, is liquefied by the cooling unit 11 and stored in the tank 10. As a result, regarding the composition ratio of the refrigerant within the refrigeration cycle, the composition ratios of low-boiling-point refrigerants, i.e., HFC32 and HFC125, are small, and the composition ratio of the high-boiling-point refrigerant, i.e., HFC134a, is large. Regarding the composition ratio within the refrigeration cycle, it is possible to return the composition ratio of the HFC32 and HFC125 to the original state by opening the open/close valve 14. As stated above, it is possible to vary the composition of the refrigerant in the case of a three-type mixture refrigerant.

Next, an explanation will be given of an embodiment of the electrostatic capacitance type sensor 8 for detecting the composition of a mixture refrigerant. Fig. 8 is a sectional view of the electrostatic capacitance type composition detecting sensor 8 shown in Fig. 1. In Fig. 8, reference numeral 53 denotes an outer tube electrode, and reference numeral 54 denotes an inner tube electrode, both of which are hollow tubes. The inner tube electrode 54 is fixed at its both ends by stoppers 55a and 55b in which a circular groove is provided in the central portion of the outer tube electrode 53. The outer diameter of the stoppers 55a and 55b is nearly the same as the inner diameter of the outer tube electrode 53, and the side opposite to the inner tube electrode holding side is fixed by the refrigerant introduction pipe 59 having an outer diameter nearly the same as the inner diameter of the outer tube electrode 53. In addition, the refrigerant introduction pipe 59 is fixed to the outer tube electrode 53.

As a result, the inner tube electrode 54 is fixed to the central portion of the outer tube electrode 53. An outer-tube electrode signal line 56 and an inner-tube electrode signal line 57 are connected to the outer tube electrode 53 and the inner tube electrode 54 in order to detect an electrostatic capacitance value. A signal line guide tube 58 (e.g. a hermetic terminal) for guiding the inner-tube electrode signal line 57 to the outside of the outer tube electrode 53 and for preventing the refrigerant inside from escaping to the outside, are disposed outside the inner-tube electrode signal line 57. In the stoppers 55a and 55b, at least one through passage having a size smaller than the inner diameter of the inner tube electrode 54 is disposed in the central portion thereof, and at least one passage for the refrigerant is disposed at a place between the inner tube electrode 54 and the outer tube electrode 53, so that the flow of the mixture refrigerant flowing through the inside is not obstructed.

Next, an explanation will be given of a method of detecting the composition of a mixture refrigerant by using the electrostatic capacitance type composition ratio detecting sensor 8. Fig. 9 illustrates the relationship between the composition ratio of the refrigerant and the electrostatic capacitance value when the electrostatic capacitance sensor is used. Fig. 9 illustrates measured values obtained when HFC134a is used as a high boiling-point refrigerant and HFC32 is used as a low boiling-point refrigerant from among the mixture refrigerant and they are sealed in the composition ratio detecting sensor shown in Fig. 8 as gas and liquid, respectively. The horizontal axis indicates the composition ratio of the HFC32, and the vertical axis indicates the electrostatic capacitance value which is an output from the composition ratio detecting sensor 8.

In Fig. 9, a comparison of the electrostatic capacitance value of gas of each refrigerant with that of liquid of each refrigerant shows that the liquid refrigerant has a larger value, and the difference between the electrostatic capacitance value of gas and that of liquid is large, in particular, in the HFC134a. This indicates that the electrostatic capacitance value varies when the dryness of the refrigerant varies. In contrast, a comparison between the electrostatic capacitance values of HFC134a and HFC32 shows that HFC32 has a larger electrostatic capacitance value for both liquid and gas. This indicates that only a gas or liquid refrigerant exists in the composition ratio detecting sensor 8, and when the composition of the refrigerant varies, the electrostatic capacitance value varies.

However, since the inside of the composition ratio detecting sensor 8 enters a two-phase state of gas and liquid, the electrostatic capacitance value varies due to the dryness of the refrigerant in addition to the composition ratio of the mixture refrigerant, it becomes impossible to detect the composition ratio. Therefore, when the composition ratio of the mixture refrigerant is detected by using the composition ratio detecting sensor 8, it is necessary to dispose the composition ratio detecting sensor 8 in a portion where the refrigerant is always gas or liquid in the refrigeration cycle. In this embodiment, since the check valves 91 to 94 are arranged, the refrigerant passing through the composition ratio detecting sensor 8 is in a liquid state. Means other than the electrostatic capacitance type may be used for the composition ratio detecting means.

Next, Fig. 10 is a flowchart illustrating a method of controlling the refrigeration cycle shown in Fig. 1. When a predetermined condition is satisfied after the refrigeration cycle is started, the composition ratio is determined on the basis of a signal from the composition ratio detecting sensor 8. A check is made to determine whether the detected composition ratio X is greater than the composition ratio X_0 of the refrigerant sealed in the refrigeration cycle. When $X > (X_0 + \alpha)$, the open/close valves 12 and 13 are opened. When the condition $(X_0 - \alpha) \leq X \leq (X_0 + \alpha)$ is satisfied, the open/close valves 12 and 13 are closed. When the detected composition ratio $X < (X_0 - \alpha)$, the open/close valve 14 is opened, and when $(X_0 - \alpha) \leq X \leq (X_0 + \alpha)$ is satisfied, the open/close valve 14 is closed. α is the tolerance.

Therefore, it is possible to control the composition of the refrigerant within the refrigeration cycle to X_0 or thereabouts, making it possible to prevent the pressure on the high pressure side from abnormally increasing and making a stable operation possible. Since the composition ratio of the nonazeotrope refrigerant can be varied, it becomes possible to vary the heating and cooling capacity as shown in Fig. 3.

Next, a second embodiment of the refrigeration cycle in accordance with the present invention is shown in Fig. 11. Fig. 11 also shows a refrigeration cycle in which the composition ratio of the non-azeotrope refrigerant can be varied, and the functions of the embodiment shown in Fig. 1 are integrated. Components in Fig. 11 having the same reference numerals as those in Fig. 1 designate identical components. Reference numerals 33 and 34 denote pipes. Reference numeral 40 denotes a refrigerant tank; reference numerals 41 and 43 denote open/close valves; and reference numerals 42 and 44 denote pipes. The refrigerant tank 40 is formed integral with the accumulator 5 as shown in Fig. 11, so that heat can be exchanged between the refrigerant tank 40 and the accumulator 5. The direction of flow of the refrigerant during heating and cooling operations is the same as in Fig. 1. In Fig. 11, it is possible to make the liquid refrigerant in the bottom portion of the accumulator 5 flow out to the tank 40 via the open/close valve 43 and stored therein.

Further, the gas refrigerant inside the receiver 6 can be condensed and liquefied by making the gas refrigerant flow into the tank 40 via the open/close valve 41 and exchanging heat with the accumulator 5. It is also possible to make the liquid refrigerant in the bottom portion of the tank 40 flow out into the accumulator 5 via the open/close valve 43 so that the liquid refrigerant is returned to the main refrigeration cycle. Therefore, by opening the open/close valve 41, it is possible to release gas having a large composition ratio of HFC32 from the main refrigeration cycle and decrease the composition ratio of HFC32. On the other hand, by opening the open/close valve 43, it is possible to release the liquid refrigerant having a large composition ratio of HFC134a from the main refrigeration cycle and decrease the composition ratio of HFC134a.

Fig. 12 is a detailed view of the receiver 6, the accumulator 5 and the tank 40, all of which are shown in Fig. 11. Components in Fig. 12 having the same reference numerals as those in Fig. 11 designate identical components. A pipe 34 through which the accumulator 5 is connected to the compressor 1 is formed into a U-shape inside the accumulator 5, and the end portion thereof is open in the upper portion of the accumulator 5. A hole 36 for returning oil circulating within the refrigeration cycle is disposed in the bottommost portion of the U-shape, and a hole 35 for making a part of gas flow out is disposed in the topmost portion of the U-shape. A pipe 42 and the open/close valve 41 are connected to each other at an appropriate position in the upper portion of the receiver 6 and at an appropriate position in the upper portion of the refrigerant tank 40. Further, a pipe 44 and the open/close valve 43 are connected to each other at appropriate positions of the lower portion of the accumulator 5 and the refrigerant tank 40. Although the refrigerant tank 40 is formed integral in the lower portion of the accumulator 5 in Fig. 12, the refrigerant tank 40 may be arranged in any way if heat can be exchanged between the accumulator 5 and the refrigerant tank 40.

Fig. 13 is a flowchart for controlling the refrigeration cycle shown in Fig. 11. When a predetermined condition is satisfied after the refrigeration cycle is started, the composition ratio is determined on the basis of a signal from the composition ratio detecting sensor. A check is made to determine whether the detected composition ratio X is greater than the composition ratio X_0 of the refrigerant sealed in the refrigeration cycle. When $X > (X_0 + \alpha)$, the open/close valve 41 is opened. When the condition $(X_0 - \alpha) \leq X \leq (X_0 + \alpha)$ is satisfied, the open/close valve 41 is closed. When the detected composition ratio $X < (X_0 + \alpha)$ and $X < (X_0 - \alpha)$, the open/close valve 43 is opened. When $(X_0 - \alpha) \leq X \leq (X_0 + \leq)$ is satisfied, the open/close valve 43 is closed. Therefore, it is possible to control the composition of the refrigerant within the refrigeration cycle to X_0 or thereabouts, making a stable operation possible. Since the composition ratio of the nonazeotrope refrigerant can be varied, it becomes possible to vary the heating and cooling capacity as shown in Fig. 3.

Claims

1. Refrigeration cycle using a non-azeotrope refrigerant and comprising
   - a compressor (1),
   - a heat-source-side heat exchanger (2),
   - a use-side heat exchanger (20a, 20b),
   - a refrigerant pressure reducing apparatus (7),
   - a refrigerant receiver (6) disposed between a side of said heat-source-side heat exchanger (2) and said useside heat exchanger (20a, 20b), whereby said side is opposite to another side of said heat-source-side heat exchanger (2) connected to said compressor (1),
   - a composition ratio detecting means (8) arranged for detecting a composition ratio of the refrigerant, and
   - composition ratio control means (10 to 15, 40 to 44)

   characterized in that
   - the composition ratio detecting means (8) is disposed between said heat-source-side heat exchanger (2) and said receiver (6), and
   - the composition ratio control means (10 to 15, 40 to 44) are arranged for taking out gas refrigerant from said receiver (6) on the basis of the composition ratio of the refrigerant detected by said composition ratio detecting means (8) so as to vary the refrigerant composition ratio mainly used in said refrigeration cycle.

2. Refrigeration cycle according to claim 1, characterized in that
   - the refrigeration cycle comprises an accumulator (5) arranged for supplying the compressor (1) with refrigerant, and
   - the composition ratio control means comprise
     - a refrigerant tank (10) connected with
       - the receiver (6) via a first pipe comprising a first open/close valve (13), and
       - the accumulator (5) via a second pipe (15) comprising a second open/close valve (14),

       and
     - a third pipe comprising a third open/close valve (12), which third pipe is coupled with the receiver (6) at one end of the third pipe and joins the second pipe (15) between the second open/close valve (14) and the accumulator (5),

   whereby
   - a part of the third pipe is embedded into a part of the first pipe, which parts in such a way form a cooling unit (11),
   - the first open/close valve (13) and the third open/close valve (12) are arranged between

the cooling unit (11) and the receiver (6),

- the receiver (6), the refrigerant tank (10), the cooling unit (11), the first pipe, the third pipe, the first open/close valve (13), and the third open/close valve (12) are arranged such that when the first and third open/close valves (13, 12) are open

  - liquid refrigerant in a bottom of the receiver (6) flows out through the third open/close valve (12) thereby being transformed into a low-temperature refrigerant by a pressure reducing effect of the third open/close valve (12),
  - gas refrigerant inside the receiver (6) flows out through the first open/close valve (13), condenses in the cooling unit (11) and is then guided as liquid into the refrigerant tank (10),

and

- the refrigerant tank (10), the second pipe (15), the third pipe, the second open/close valve (14), the third open/close valve (12), and the accumulator (5) are arranged such that the liquid stored in the refrigerant tank (10) can be discharged to the accumulator (5) through the second pipe (15) when the third open/close valve (12) is closed and the second open/close valve (14) is open.

3. Refrigeration cycle according to claim 1, characterized in that

- the refrigeration cycle comprises an accumulator (5) arranged for supplying the compressor (1) with refrigerant, and
- the composition ratio control means comprise

  - a refrigerant tank (40) connected with

    - the receiver (6) via a first pipe (42) comprising a first open/close valve (41), and
    - the accumulator (5) via a second pipe (44) comprising a second open/close valve (43),

whereby

- the accumulator (5) and the refrigerant tank (40) are arranged such that heat can be exchanged between the refrigerant tank (40) and the accumulator (5),
- the receiver (6), the refrigerant tank (40), the first pipe (42) and the first open/close valve (41) are arranged such that when the first open/close valve (41) is open gas refrigerant inside the receiver (6) flows out through the first pipe (42) into the refrigerant tank (40) where it is condensed to liquid due to the heat exchange with the accumulator (5), and
- the refrigerant tank (40), the second pipe (44), the second open/close valve (43), and the accumulator (5) are arranged such that the liquid stored in the refrigerant tank (40) can be discharged to the accumulator (5) through the second pipe (44) when the second open/close valve (43) is open.

4. Refrigeration cycle according to claim 3, characterized in that the refrigerant tank (40) is formed integral in a lower portion of the accumulator (5).

5. Refrigeration cycle according to claim 1, characterized in that the composition ratio detecting means (8) is an electrostatic capacitance type sensor.

FIG. 1

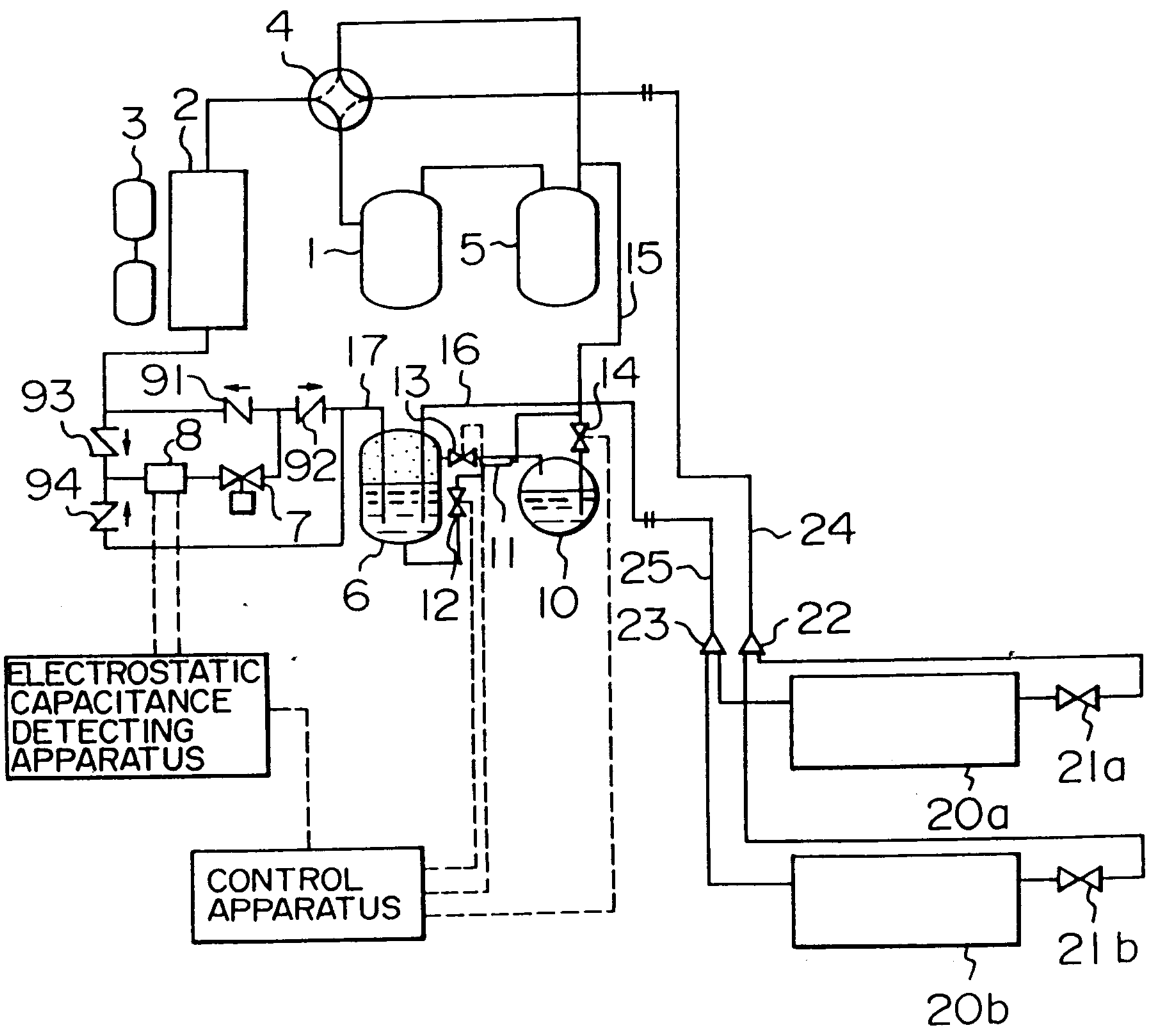

4
3
2
1
5
15
17
16
13
14
91
92
93
8
94
7
6
12
11
10
24
25
23
22
ELECTROSTATIC CAPACITANCE DETECTING APPARATUS
21a
20a
CONTROL APPARATUS
21b
20b

FIG. 2

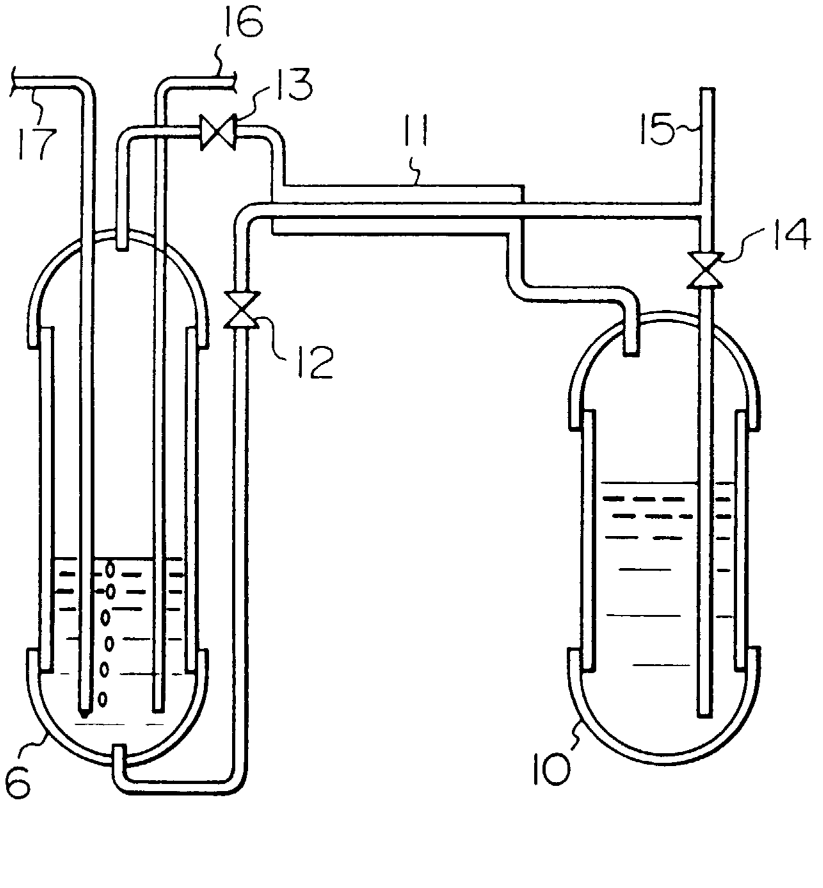
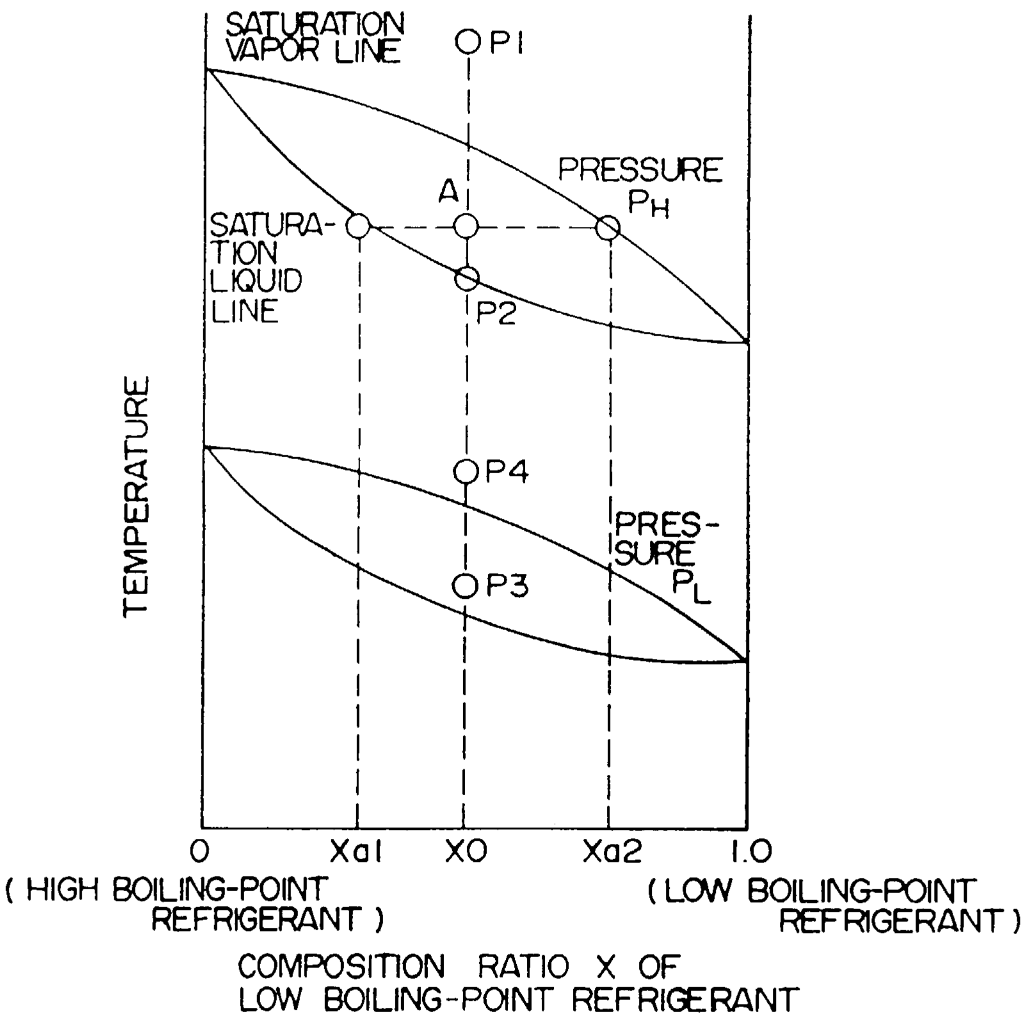


FIG. 3


SATURATION VAPOR LINE
P1
PRESSURE P_H
A
SATURATION LIQUID LINE
P2
TEMPERATURE
P4
PRESSURE P_L
P3
0
Xa1
X0
Xa2
1.0
(HIGH BOILING-POINT REFRIGERANT)
(LOW BOILING-POINT REFRIGERANT)
COMPOSITION RATIO X OF LOW BOILING-POINT REFRIGERANT

F I G. 4

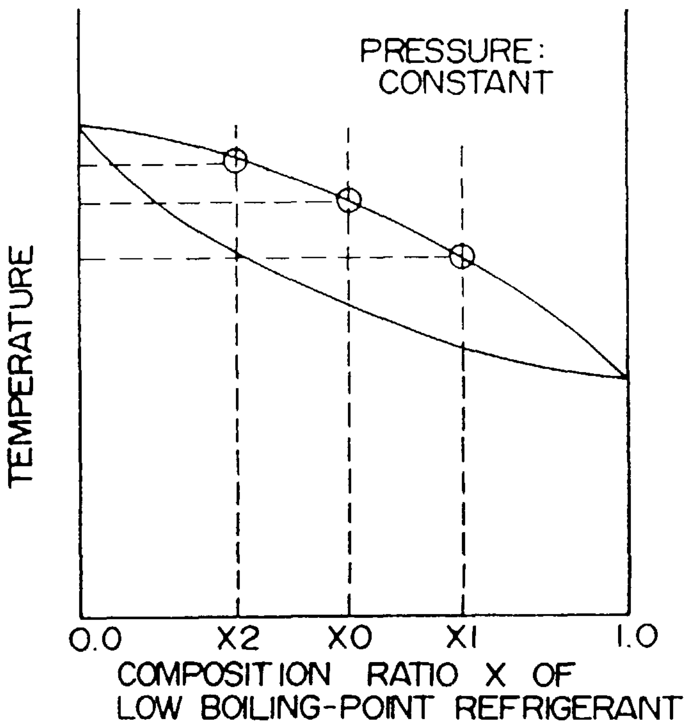

PRESSURE:
CONSTANT
TEMPERATURE
0.0
X2
X0
X1
1.0
COMPOSITION RATIO X OF
LOW BOILING-POINT REFRIGERANT

FIG. 5

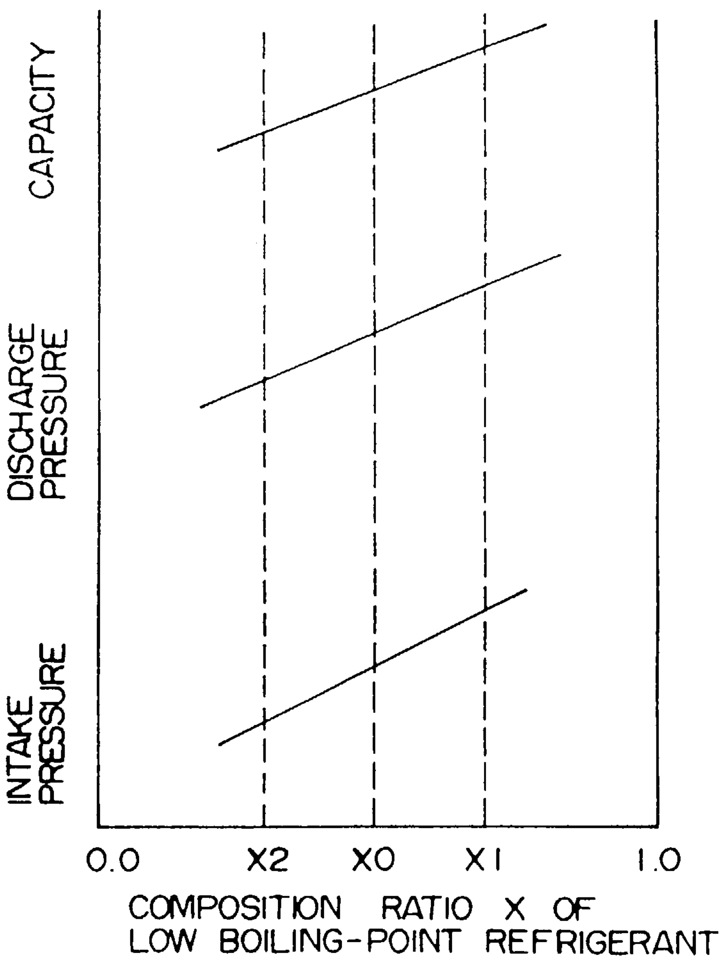

CAPACITY
DISCHARGE PRESSURE
INTAKE PRESSURE
0.0
X2
X0
X1
1.0
COMPOSITION RATIO X OF LOW BOILING-POINT REFRIGERANT

FIG. 6

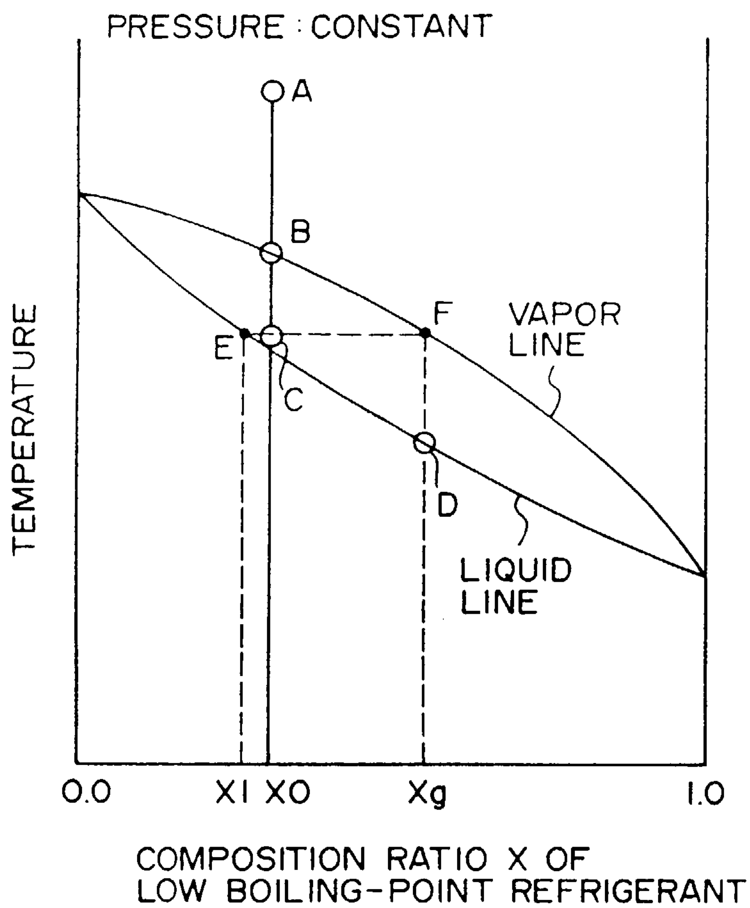

PRESSURE : CONSTANT
A
B
F
VAPOR LINE
E
C
D
LIQUID LINE
TEMPERATURE
0.0
X1
X0
Xg
1.0
COMPOSITION RATIO X OF LOW BOILING-POINT REFRIGERANT

FIG. 7

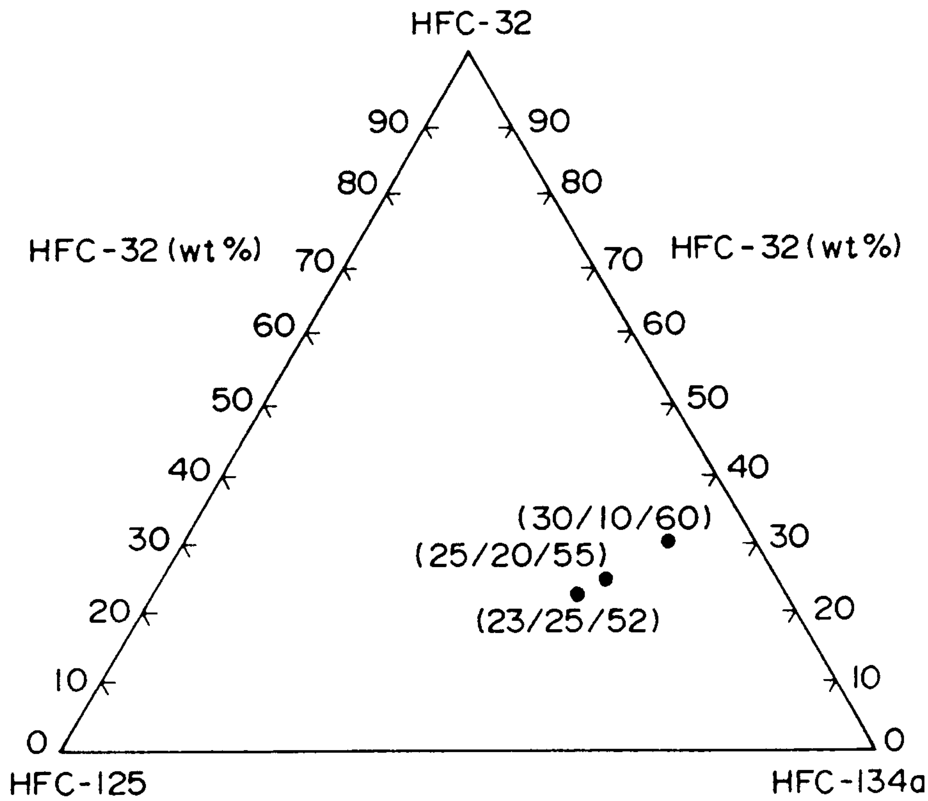

HFC-32
HFC-32 (wt %)
HFC-32 (wt %)
90
80
70
60
50
40
30
20
10
0
(30/10/60)
(25/20/55)
(23/25/52)
HFC-125
HFC-134a

FIG. 8

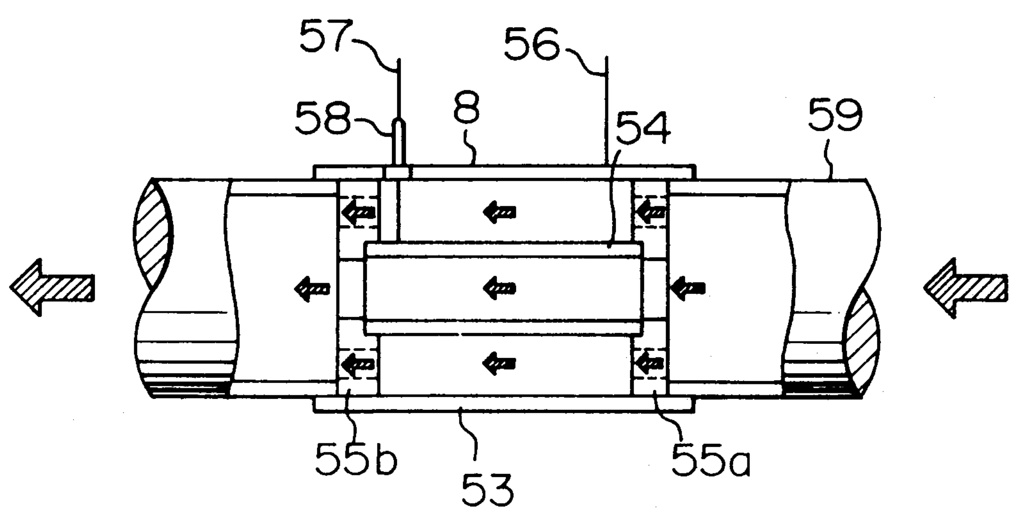

57
56
58
8
54
59
55b
53
55a

FIG. 9

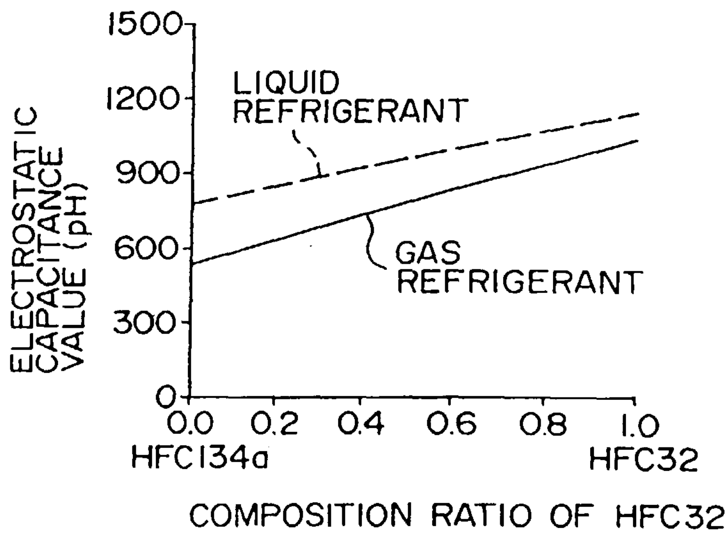
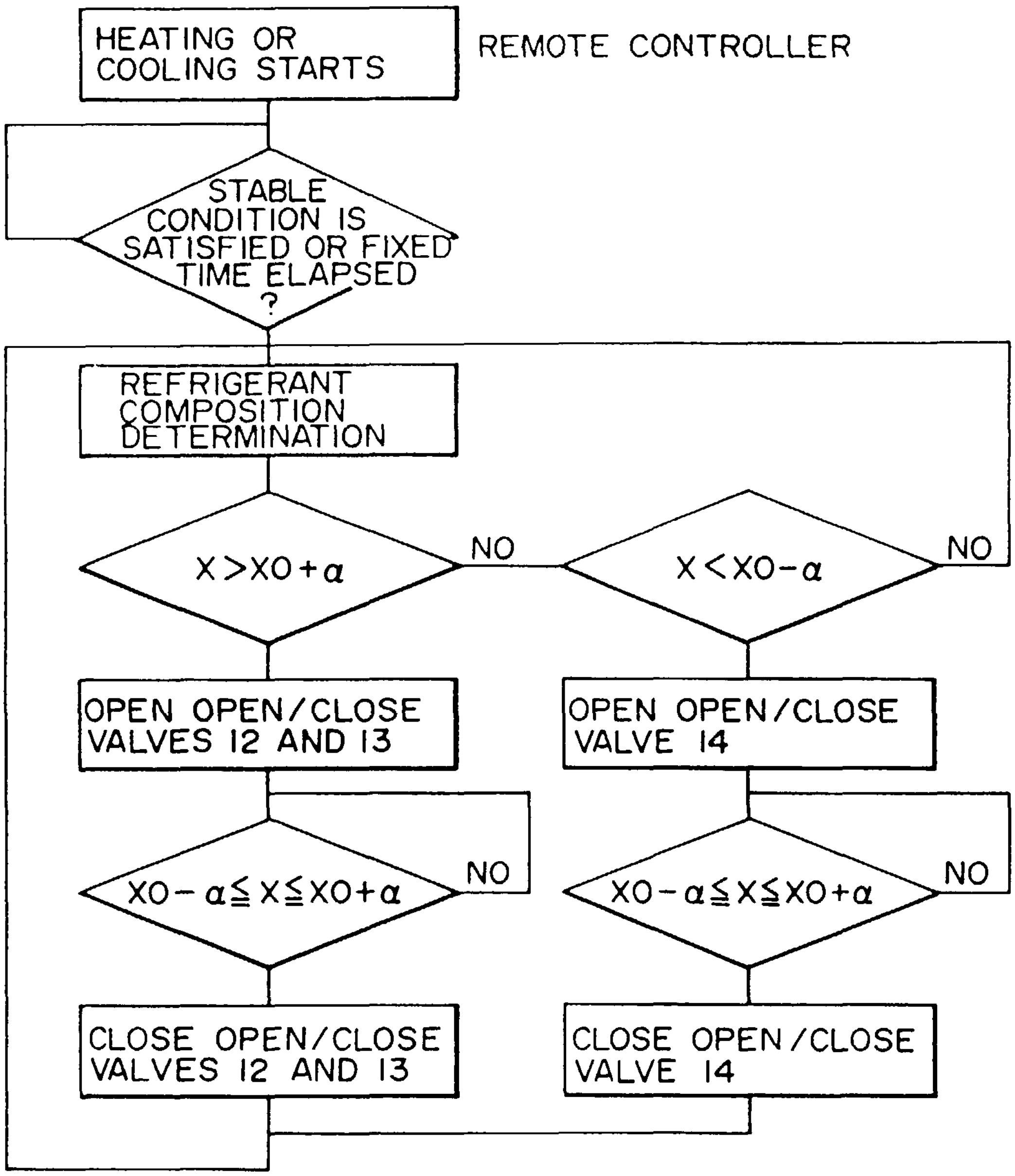

1500
1200
900
600
300
0
LIQUID
REFRIGERANT
GAS
REFRIGERANT
ELECTROSTATIC
CAPACITANCE
VALUE (pH)
0.0
0.2
0.4
0.6
0.8
1.0
HFC134a
HFC32
COMPOSITION RATIO OF HFC32

FIG. 10


HEATING OR COOLING STARTS
REMOTE CONTROLLER
STABLE CONDITION IS SATISFIED OR FIXED TIME ELAPSED ?
REFRIGERANT COMPOSITION DETERMINATION
X>XO+α
NO
X<XO-α
NO
OPEN OPEN/CLOSE VALVES 12 AND 13
OPEN OPEN/CLOSE VALVE 14
XO-α≦X≦XO+α
NO
XO-α≦X≦XO+α
NO
CLOSE OPEN/CLOSE VALVES 12 AND 13
CLOSE OPEN/CLOSE VALVE 14

F I G. 11

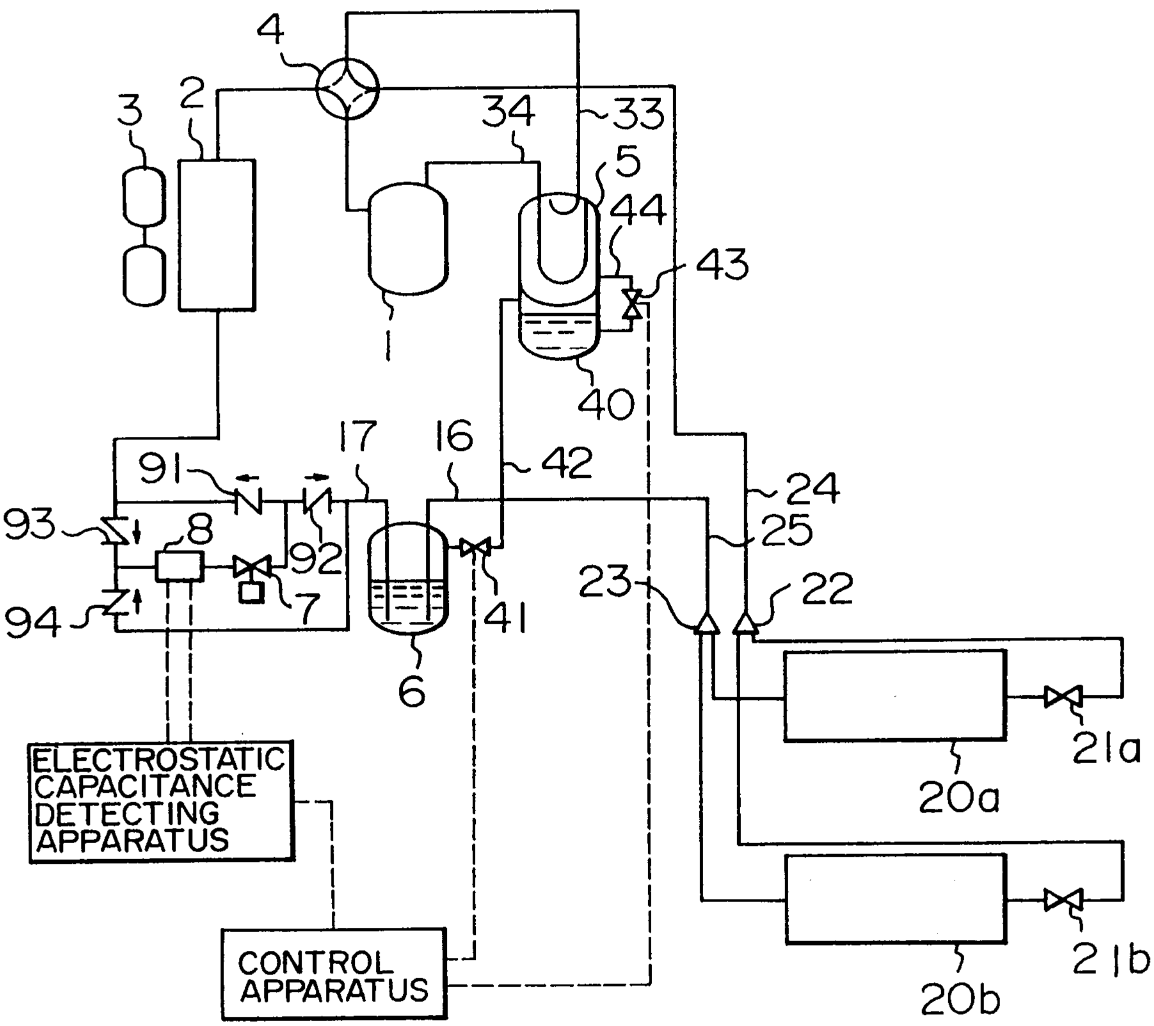

4
3
2
34
33
5
44
43
1
40
17
16
42
24
91
93
8
92
25
23
22
7
41
94
6
21a
20a
ELECTROSTATIC CAPACITANCE DETECTING APPARATUS
CONTROL APPARATUS
21b
20b

FIG. 12

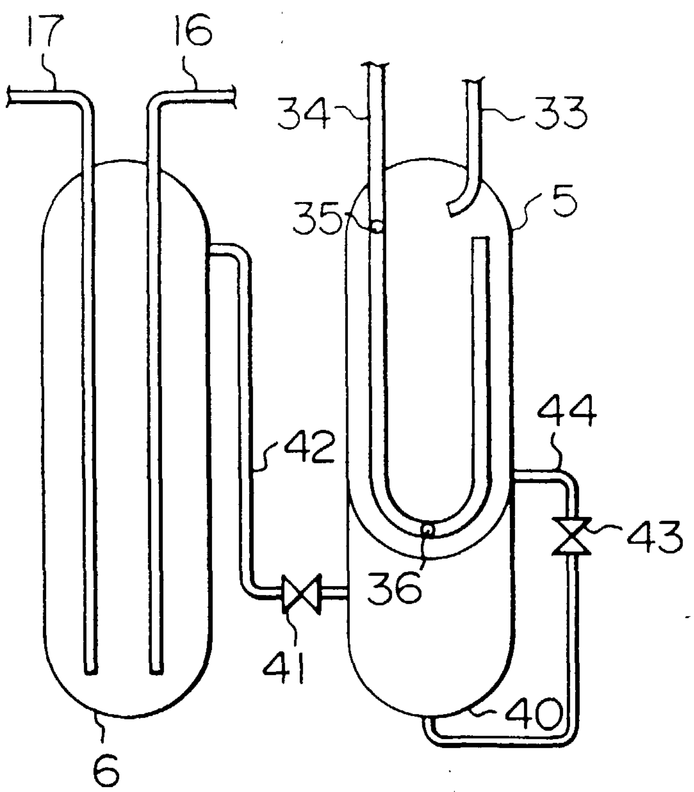
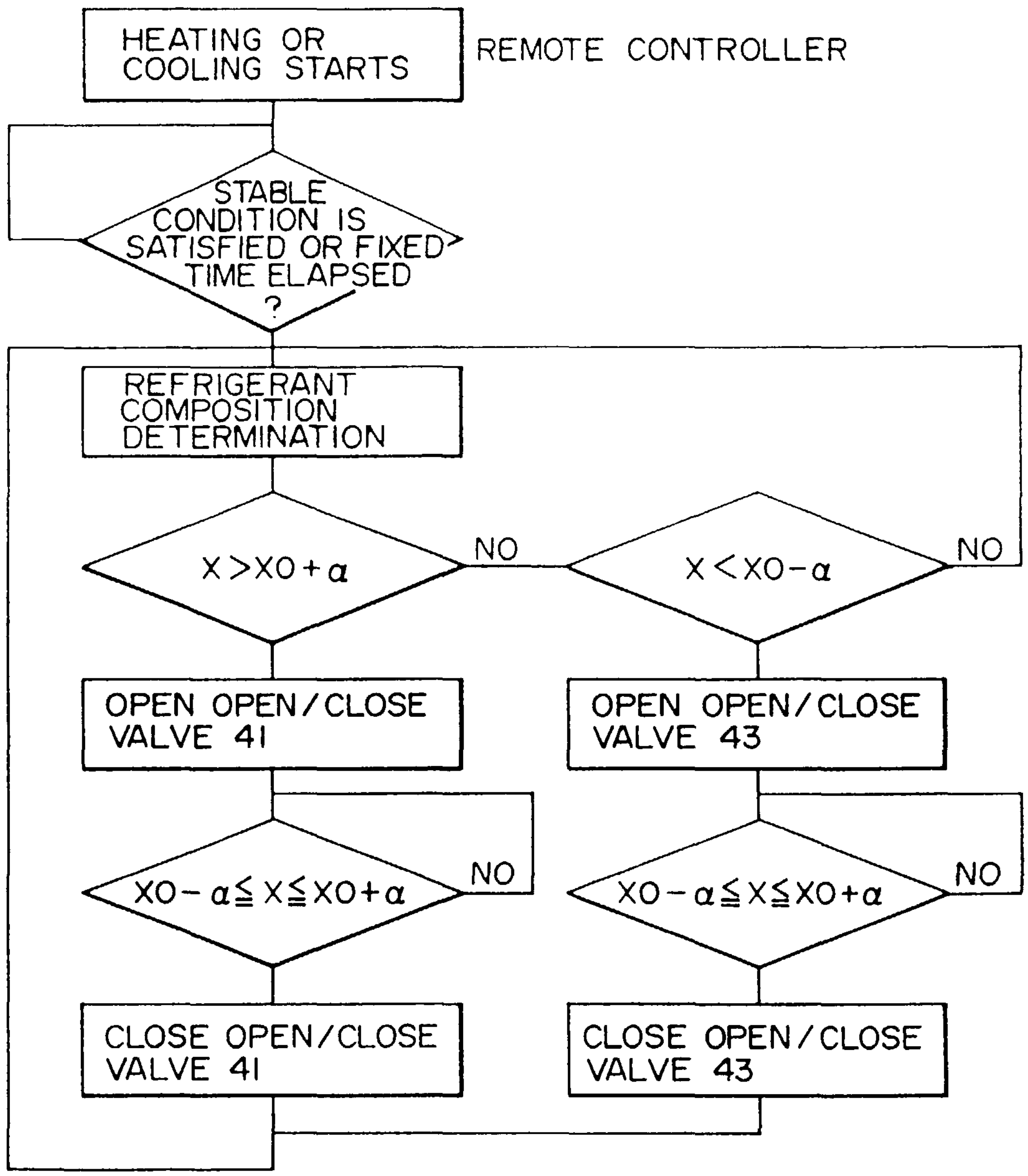


FIG. 13


HEATING OR COOLING STARTS
REMOTE CONTROLLER
STABLE CONDITION IS SATISFIED OR FIXED TIME ELAPSED ?
REFRIGERANT COMPOSITION DETERMINATION
X>XO+α
NO
X<XO-α
NO
OPEN OPEN/CLOSE VALVE 41
OPEN OPEN/CLOSE VALVE 43
XO-α≦X≦XO+α
NO
XO-α≦X≦XO+α
NO
CLOSE OPEN/CLOSE VALVE 41
CLOSE OPEN/CLOSE VALVE 43